MAPSS and AeroStat: integrated analysis of aerosol measurements using Level 2 Data and Point Data in Giovanni

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Presented at the 2012 Gregory G. Leptoukh Online Giovanni Workshop, September 25-27, 2012

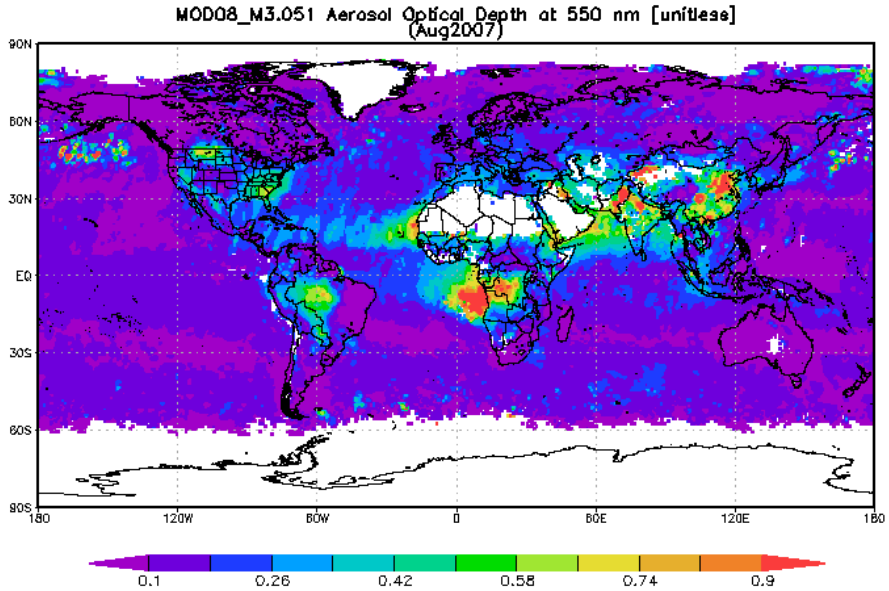
Aerosols

- Impact air quality, hydrological cycle, climate
- Aerosol measurements available from multiple spaceborne and ground-based sensors, *however:*
  - Which of the available aerosol product to use?
    - At what location?
    - At what season?
    - Under what conditions?
- It is necessary to cross-validate aerosol products to better understand their relative uncertainties and limitations

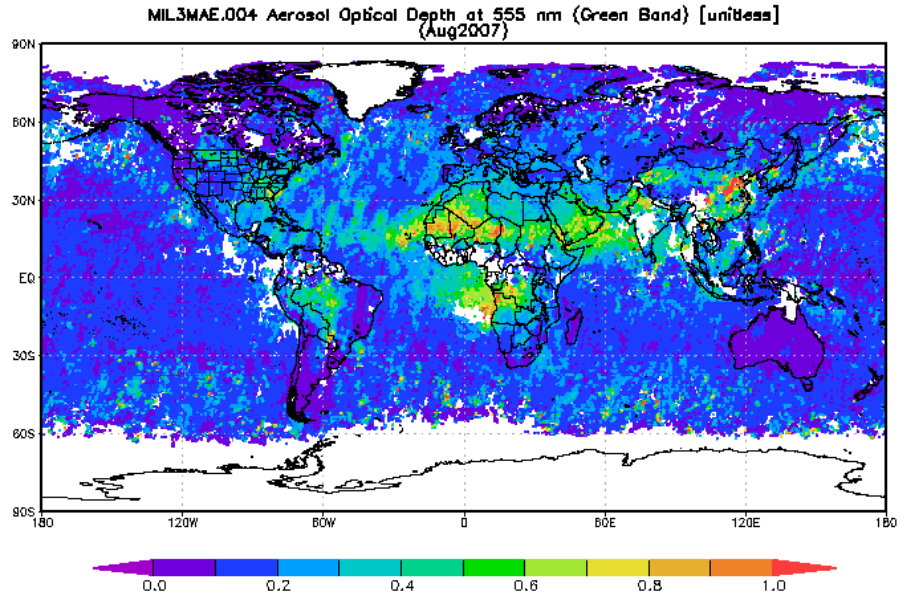
Multi-sensor aerosol analysis using Giovanni

http://disc.sci.gsfc.nasa.gov/giovanni/

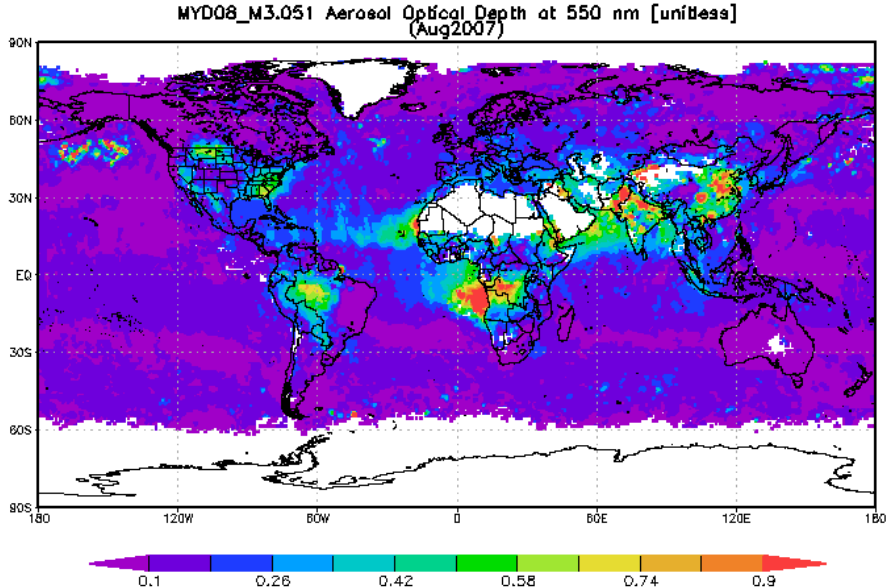
Global AOD during August 2007



MODIS Terra



MISR

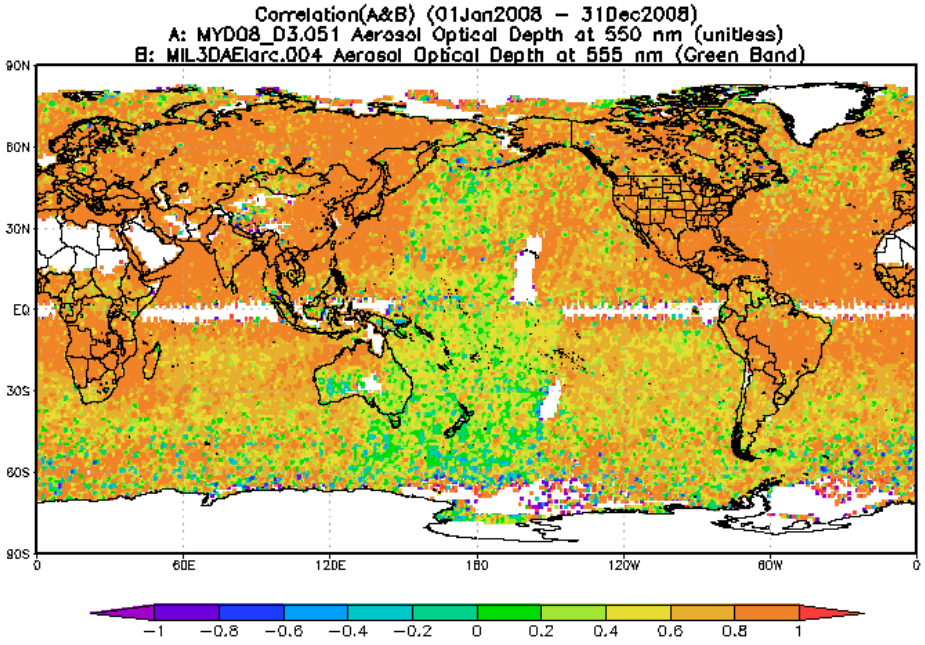


MODIS Aqua

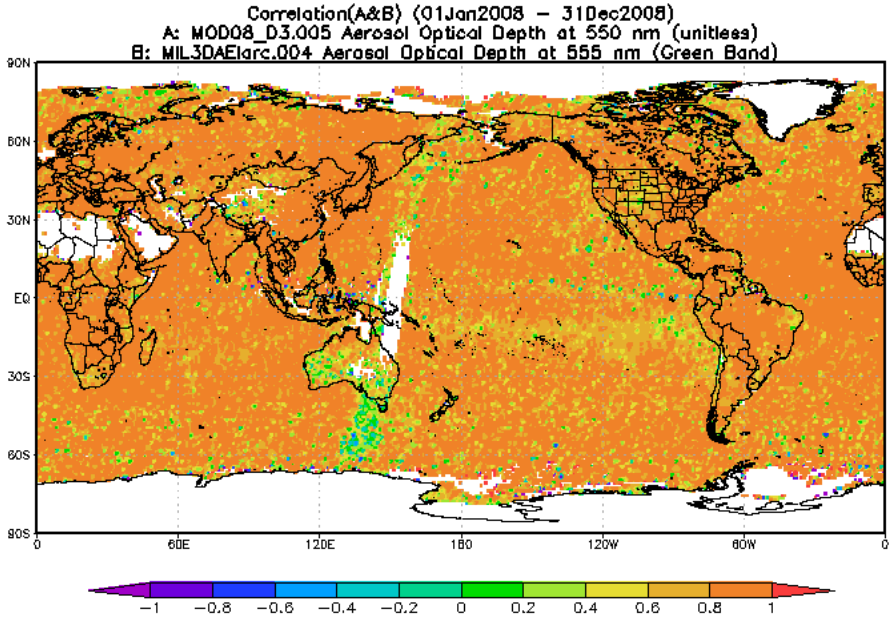
Aerosol Sensors and Products

Sensor	Platform	Spatial Resolution (Level 2)	Equator crossing time*	Data period	Features
AERONET	Ground-based	N/A	N/A	Varies with sites	High accuracy
MODIS	Terra Aqua	10x10 km	10:30 am 1:30 pm	Jan'00- Jul'02-	High spatial coverage
MISR	Terra	17.6x17.6 km	10:30 am	Jan'00-	Multiple viewing angles
OMI	Aura	13.7x23.7 km	1:38 pm	Oct'04-	Absorption, SSA
POLDER	ADEOS ADEOS-2 PARASOL	19x19 km	1:30 pm	Oct'96-Jun'97 Apr'03-Oct'03 Mar'05-	Polarization
CALIOP	CALIPSO	5x0 km	1:32 pm	Jun'06-	Vertical profile
SeaWiFS	SeaStar	13.5x13.5 km	12:00 pm	Jan'98-Dec'10	The longest time span, precise calibration

Challenges in multi-sensor analysis using Level-3 data



<<< AOD Aqua MODIS vs MISR correlation map for 2008



MODIS-Terra vs. MISR-Terra: Map of AOD temporal correlation >>>

Image credit: Gregory Leptoukh, David Lary, Suhung Shen, Christopher Lynnes

Aerosol retrieval reference: AERONET

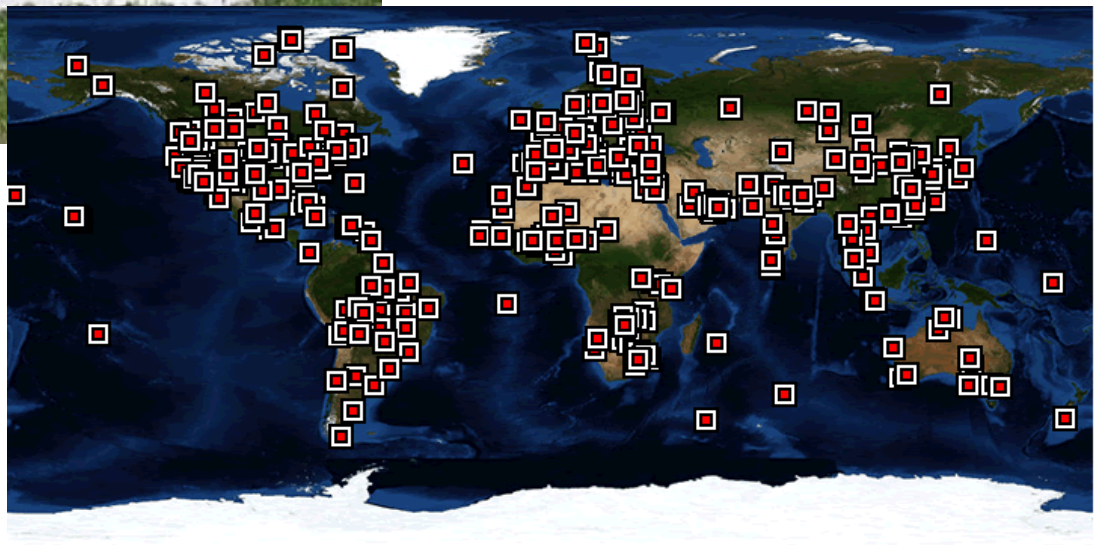
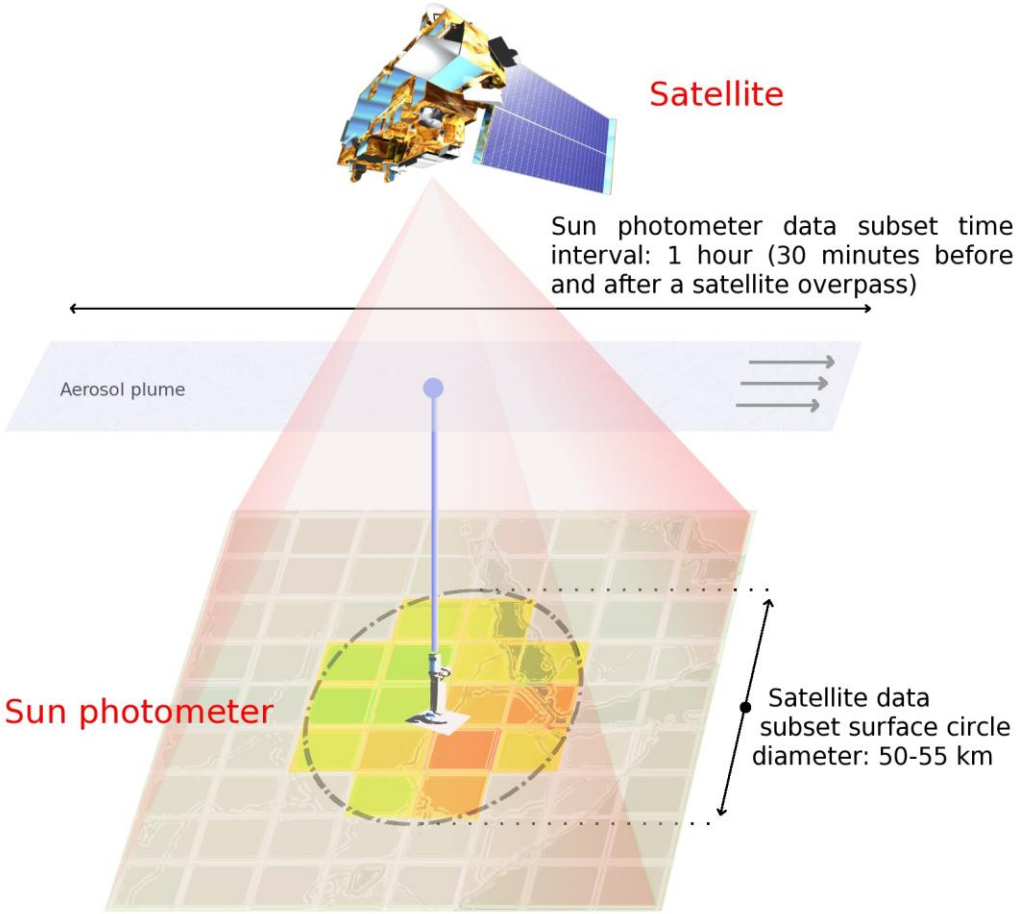


Image credit: aeronet.gsfc.nasa.gov

- Aerosol data are available from different sensors
  - MODIS
  - MISR
  - OMI
  - POLDER
  - CALIOP
  - AERONET

- Hard to compare and inter-validate
  - Different spatial and temporal resolution
  - Different data access strategies

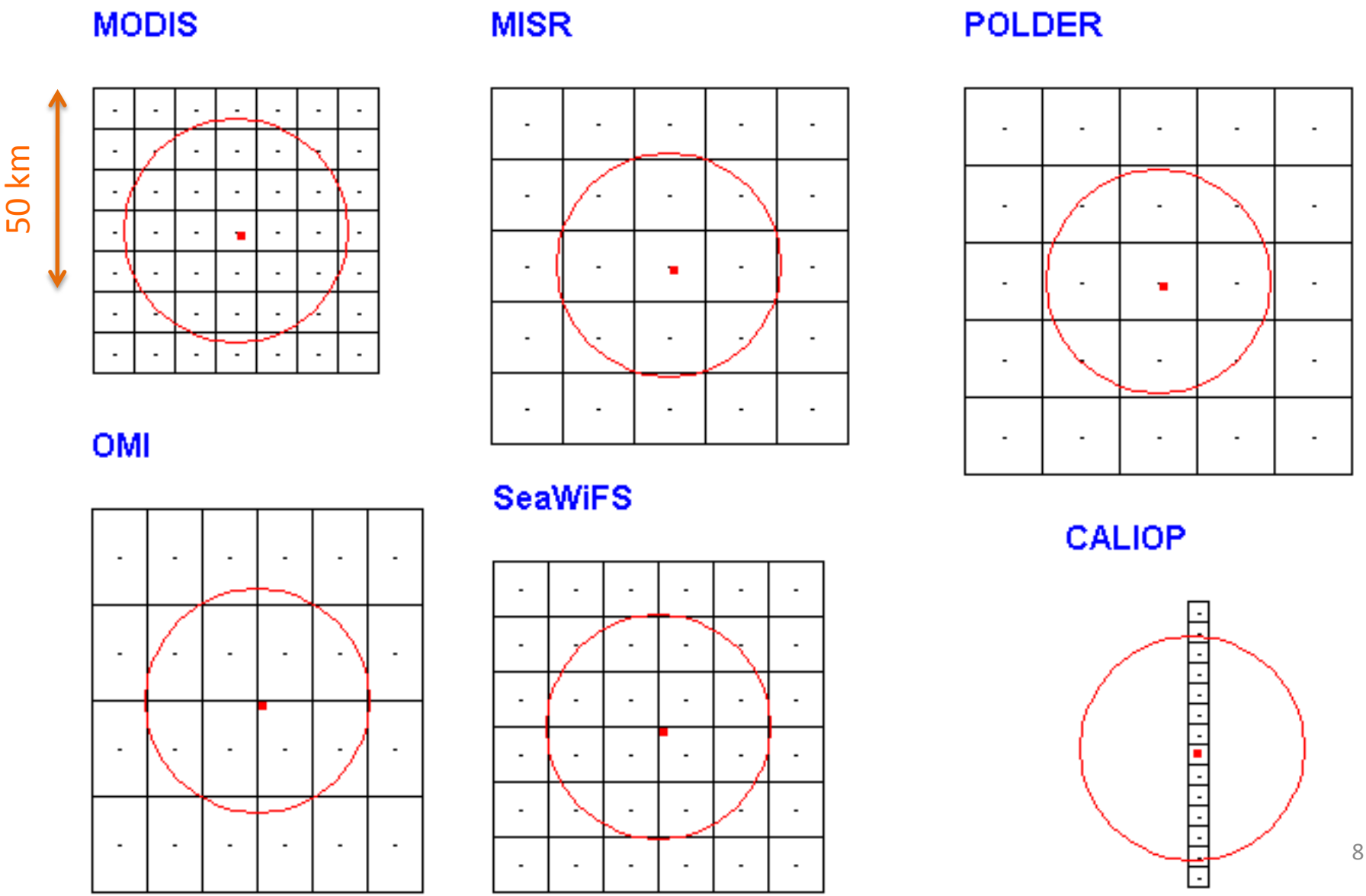
MAPSS: Multi-sensor Aerosol Products Sampling System



MAPSS uniformly samples Level-2 aerosol products and stores resulting statistics in simple CSV files

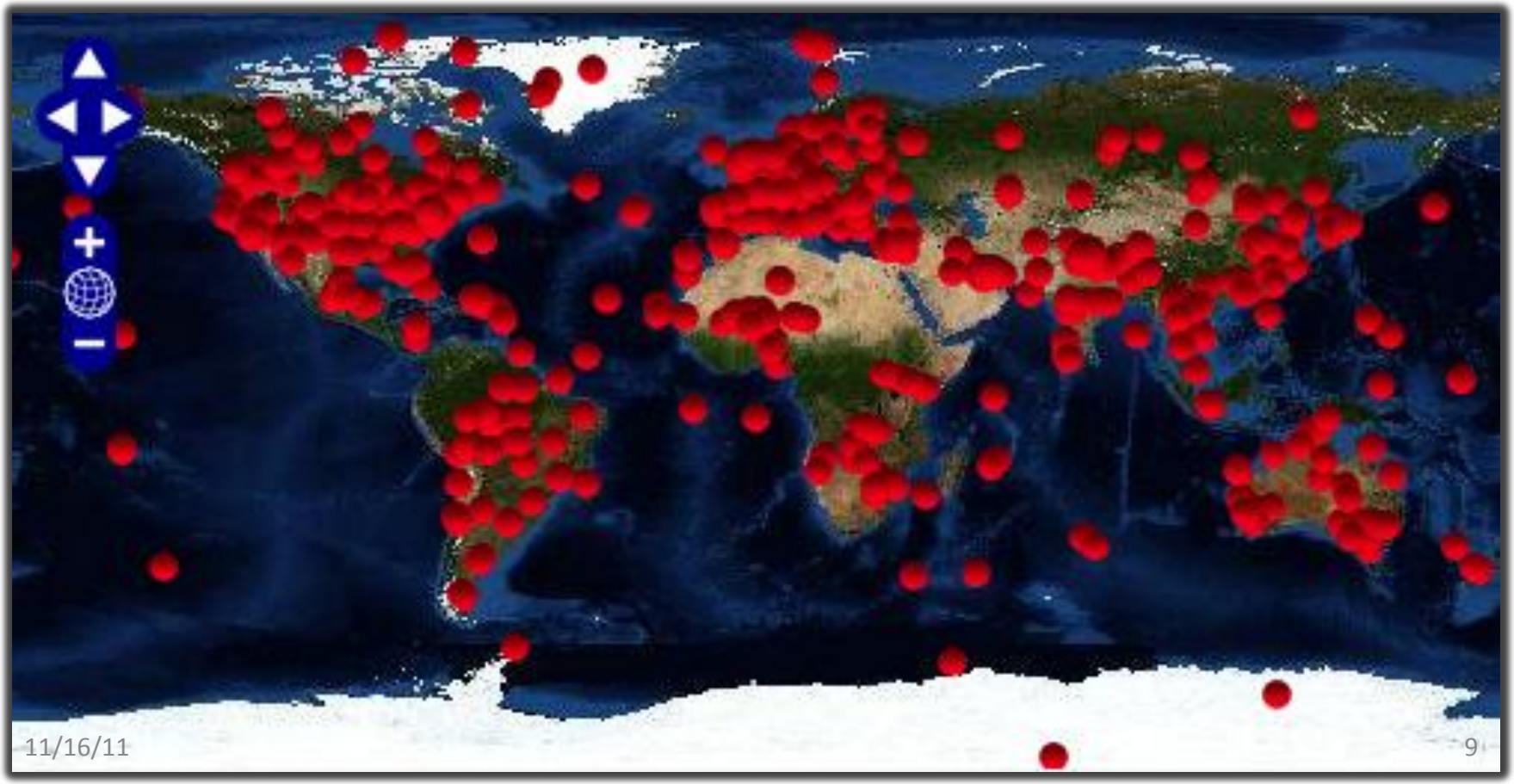
Giovanni-based WEB interface for MAPSS provides a convenient customized access to the data, with on-line plotting and data export capabilities

Sensor ground footprint (at nadir)



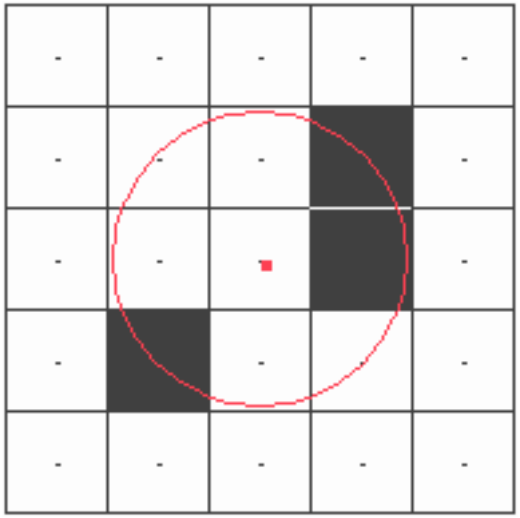
MAPSS coverage

- 659 sampling locations
  - 540 AERONET locations



Subset statistics

- General
  - Number of pixels in sample space (Ndat)
  - Valid pixel count (Nval)
  - Closest pixel value (Cval)
  - Mean, Median, Mode
  - Standard Deviation



Ndat=9
Nval =6

- Spatio-temporal variability
  - Slope of fitted Plane or Line
  - Azimuth (direction) of slope
  - Multiple (or Linear) Correlation Coefficient

Additional subset data

- Geometry
  - Solar zenith angle
  - Sensor zenith angle
  - Scattering angle
  - … and so on
- Data provenance
  - Name of source data file
  - Index of the closest pixel in the data file
- Quality control / Quality assurance (QA)
  - Mode or mean of QA flags in the subset area
  - Bit mask flags are decoded and reported as plain numbers

MAPSS data files

Each line represents a single data point, and contains:

- Date, Time, Location (Name and Lat/Lon)
- Geometry
- QA
- Layers, each containing statistics for a particular aerosol parameter

Date	Time	Orbit	HDFfile	Location	Longitude	Latitude	block	irowc	icolc	ndat	nchan	QAb	cval_AOD0446b	nval_AOD0446b	mean_AOD0446b	medn_AOD0446b	sdev_AOD...	slop_AOD...	slaz_AOD0446b	mcoc_AOD0446b	cval_AOD0558b	nval_AOD...	mean_AO...
2009-11-30	17:31	52940	MISR_AM1_...	CART_SITE	-97.486	36.607	61	5	24	8	4	1	0.073	7	0.073	0.071	0.0070	3.642	48.41	0.938	0.052	7	0.054
2009-11-30	17:31	52940	MISR_AM1_...	Cart_Site	-97.486	36.607	61	5	24	8	4	1	0.073	7	0.073	0.071	0.0070	3.642	48.41	0.938	0.052	7	0.054
2009-11-30	17:25	52940	MISR_AM1_...	Churchill	-93.818	58.736	44	1	4	7	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	17:32	52940	MISR_AM1_...	Geronimo_TOM...	-97.93	29.61	66	8	32	1	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	17:30	52940	MISR_AM1_...	Hillsboro_KS	-97.301	38.305	60	2	22	7	4	1	0.044	7	0.052	0.049	0.0090	3.304	324.388	0.872	0.029	7	0.035
2009-11-30	17:31	52940	MISR_AM1_...	IHOP-Homestead	-100.606	36.558	61	7	8	7	4	1	0.048	7	0.053	0.048	0.011	4.04	200.949	0.824	0.025	7	0.031
2009-11-30	17:30	52940	MISR_AM1_...	KONZA_EDC	-96.61	39.102	59	5	25	9	4	1	0.064	9	0.051	0.05	0.0060	0.458	17.343	0.185	0.05	9	0.033
2009-11-30	17:31	52940	MISR_AM1_...	LW-SCAN	-97.979	34.96	62	8	24	8	4	1	0.075	8	0.068	0.067	0.0040	0.483	208.051	0.336	0.053	8	0.048
2009-11-30	17:31	52940	MISR_AM1_...	Lamont_OK	-97.485	36.606	61	5	24	8	4	1	0.073	7	0.073	0.071	0.0070	3.642	48.41	0.938	0.052	7	0.054
2009-11-30	17:27	52940	MISR_AM1_...	Pickle_Lake	-90.218	51.449	49	3	30	7	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	17:31	52940	MISR_AM1_...	Purcell_OK	-97.415	34.969	62	7	27	8	4	3	--	3	0.061	0.064	0.012	--	--	--	--	3	0.04
2009-11-30	17:29	52940	MISR_AM1_...	SMEX	-93.664	41.936	56	8	32	1	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	17:30	52940	MISR_AM1_...	Shelton	-98.76	40.75	58	4	12	9	4	3	--	3	0.053	0.046	0.016	--	--	--	--	3	0.033
2009-11-30	17:29	52940	MISR_AM1_...	Sioux_Falls	-96.626	43.736	55	8	16	7	4	3	--	4	0.048	0.047	0.0080	--	--	--	--	4	0.032
2009-11-30	17:32	52940	MISR_AM1_...	TSU_SM_TX	-97.946	29.888	66	8	32	4	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	17:31	52940	MISR_AM1_...	Vici_OK	-99.204	36.071	62	2	17	8	4	3	--	4	0.052	0.052	0.0040	--	--	--	--	4	0.032
2009-11-30	19:04	52941	MISR_AM1_...	Fort_McMurray	-111.476	56.752	44	7	30	8	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	19:08	52941	MISR_AM1_...	HJAndrews	-122.224	44.239	55	5	12	7	4	3	--	2	0.101	0.101	0.0040	--	--	--	--	2	0.061
2009-11-30	19:06	52941	MISR_AM1_...	Kelowna	-119.373	49.955	50	8	15	8	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	19:09	52941	MISR_AM1_...	Lake_Tahoe	-120.104	39.171	59	4	31	8	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	19:06	52941	MISR_AM1_...	Lochiel	-122.602	49.028	51	8	3	9	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	19:10	52941	MISR_AM1_...	MONTEREY	-121.79	36.8	61	4	26	8	4	3	--	2	0.083	0.083	0.0030	--	--	--	--	2	0.07
2009-11-30	19:08	52941	MISR_AM1_...	Metolius_Old_Pine	-121.622	44.499	55	3	14	8	4	3	--	1	0.073	0.073	--	--	--	--	--	1	0.06
2009-11-30	19:10	52941	MISR_AM1_...	Monterey	-121.855	36.593	61	5	26	7	4	3	--	3	0.083	0.083	0.0020	--	--	--	--	3	0.07
2009-11-30	19:10	52941	MISR_AM1_...	Moss_Landing	-121.788	36.793	61	4	26	8	4	3	--	2	0.083	0.083	0.0030	--	--	--	--	2	0.07
2009-11-30	19:07	52941	MISR_AM1_...	Richland	-119.28	46.34	53	6	22	8	4	3	--	0	--	--	--	--	--	--	--	0	---
2009-11-30	19:07	52941	MISR_AM1_...	Rimrock	-116.992	46.487	53	4	31	8	4	3	--	0	--	--	--	--	--	--	--	0	---

Auxiliary information

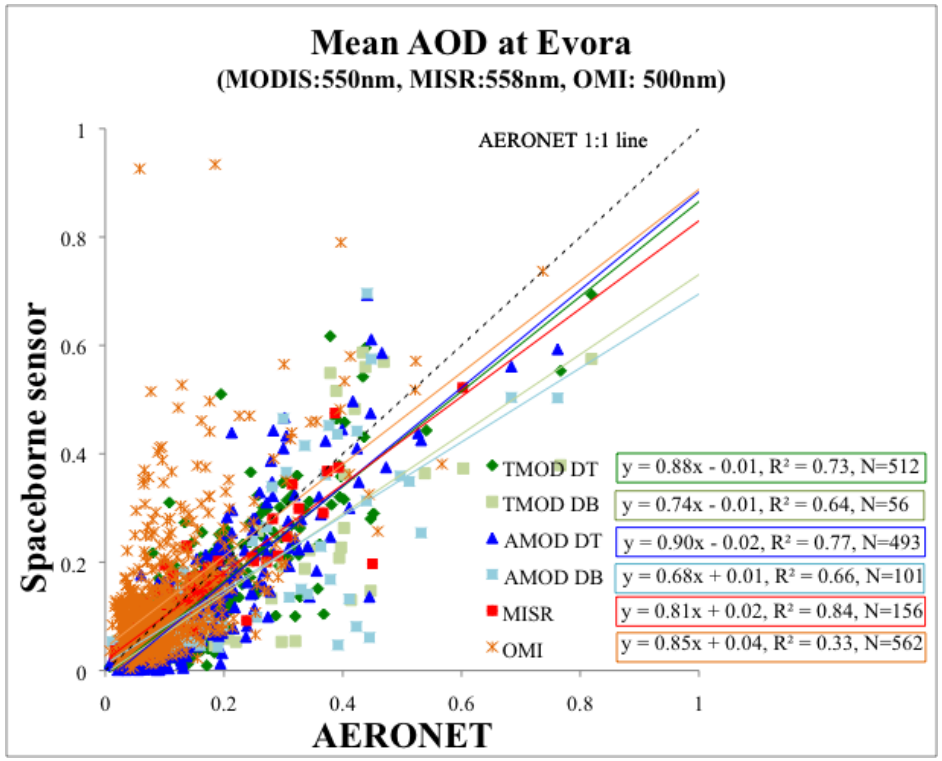
Statistics for layer 1

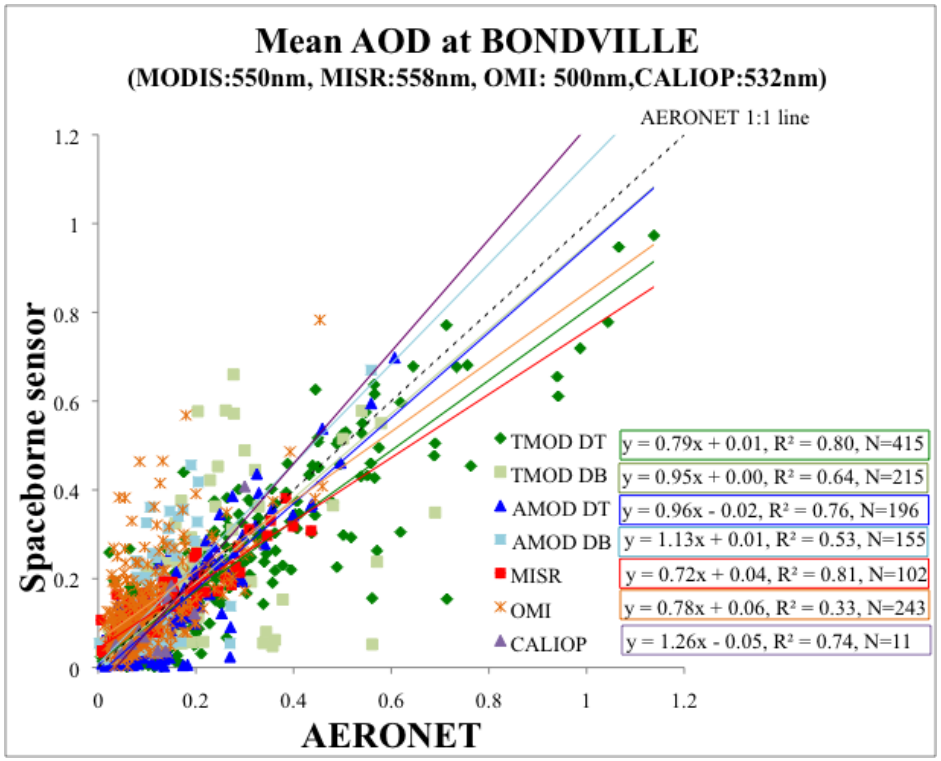
Statistics for layer 2

Sampled and stored daily to the WEB archive

http://modis-atmos.gsfc.nasa.gov/MAPSS/

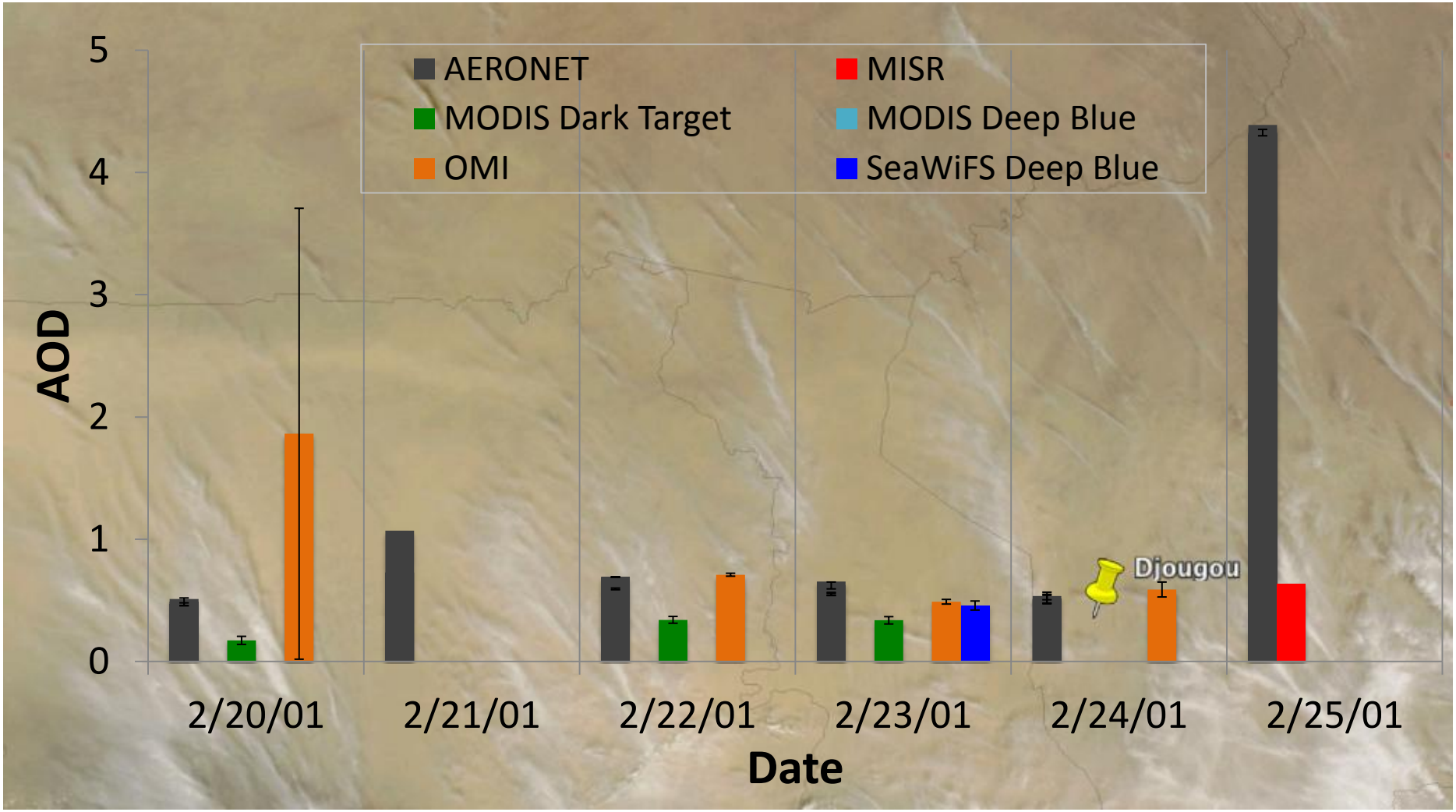
Multi-sensor AOD analysis using MAPSS





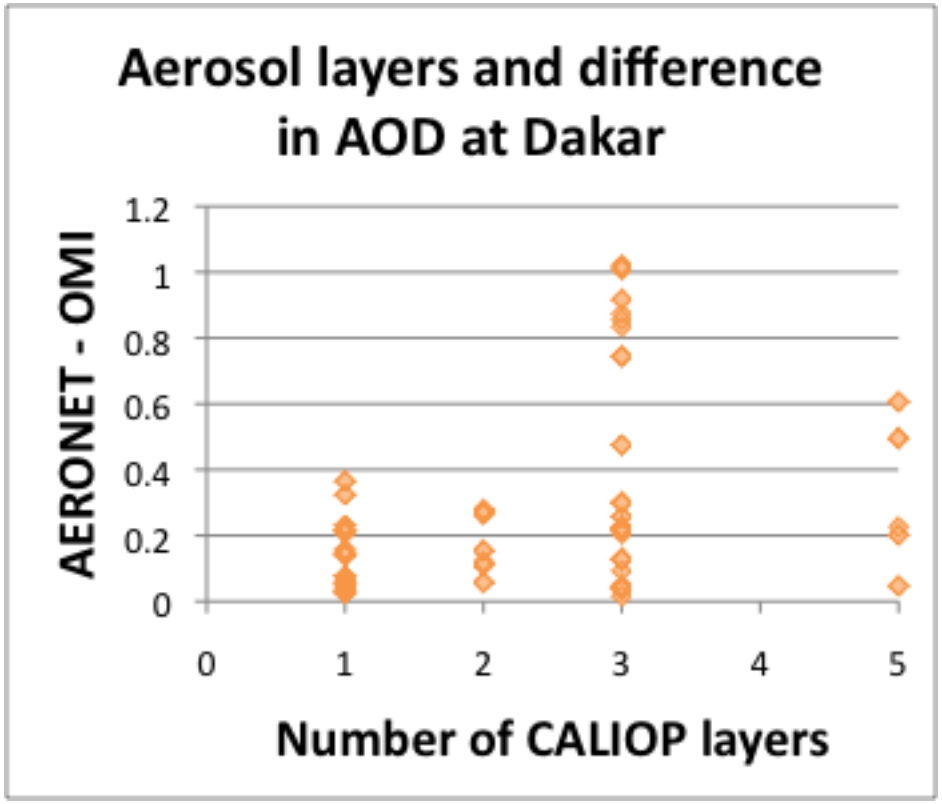
Best-QA mean AOD from multiple sensors at Djougou

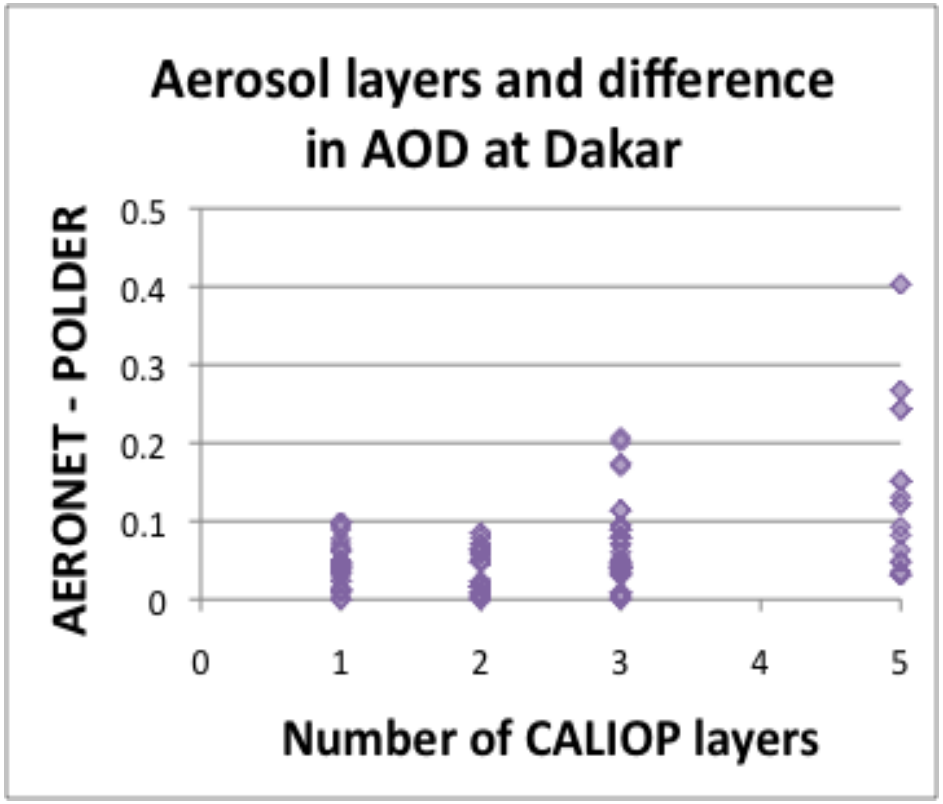
(AERONET,MODIS and SeaWiFS at 550nm, MISR at 555nm, OMI at 500nm)



- The event was observed by multiple sensors, but most best-QA measurements underestimated the actual AOD value
- Interestingly, there were no best-QA Deep Blue AOD retrievals from MODIS, but there were some from SeaWiFS

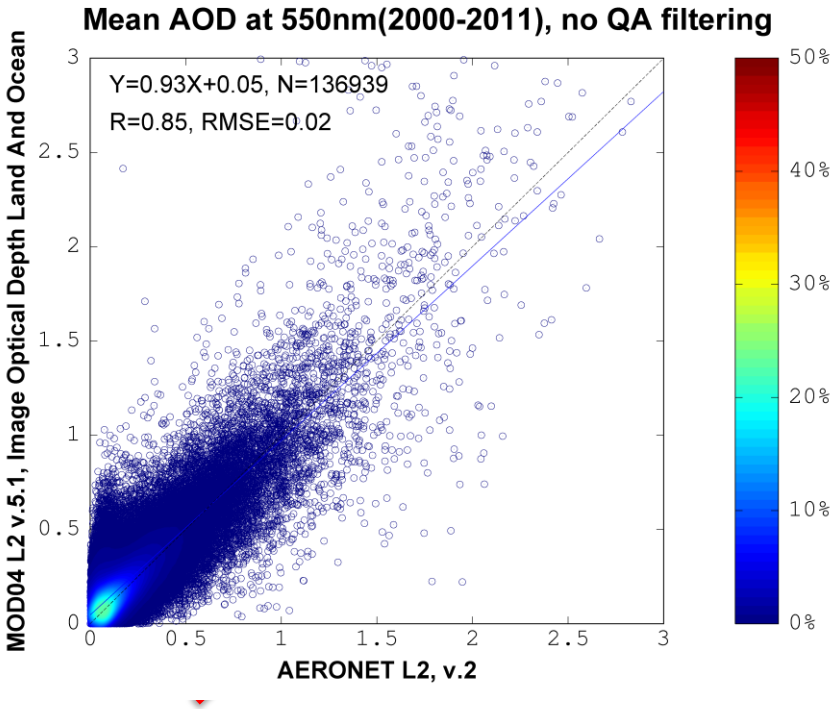
Cross-sensor multivariate analysis



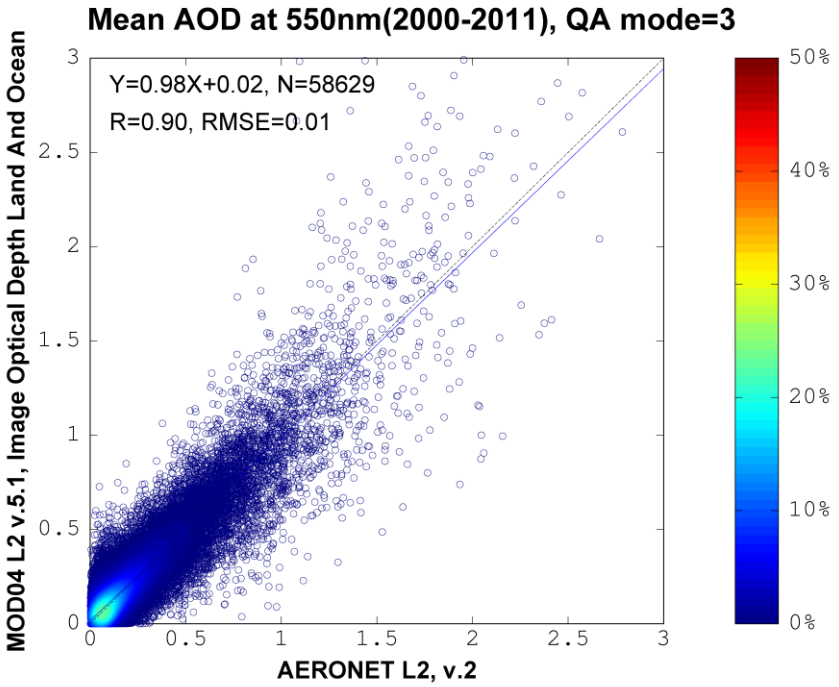


Accounting for data quality

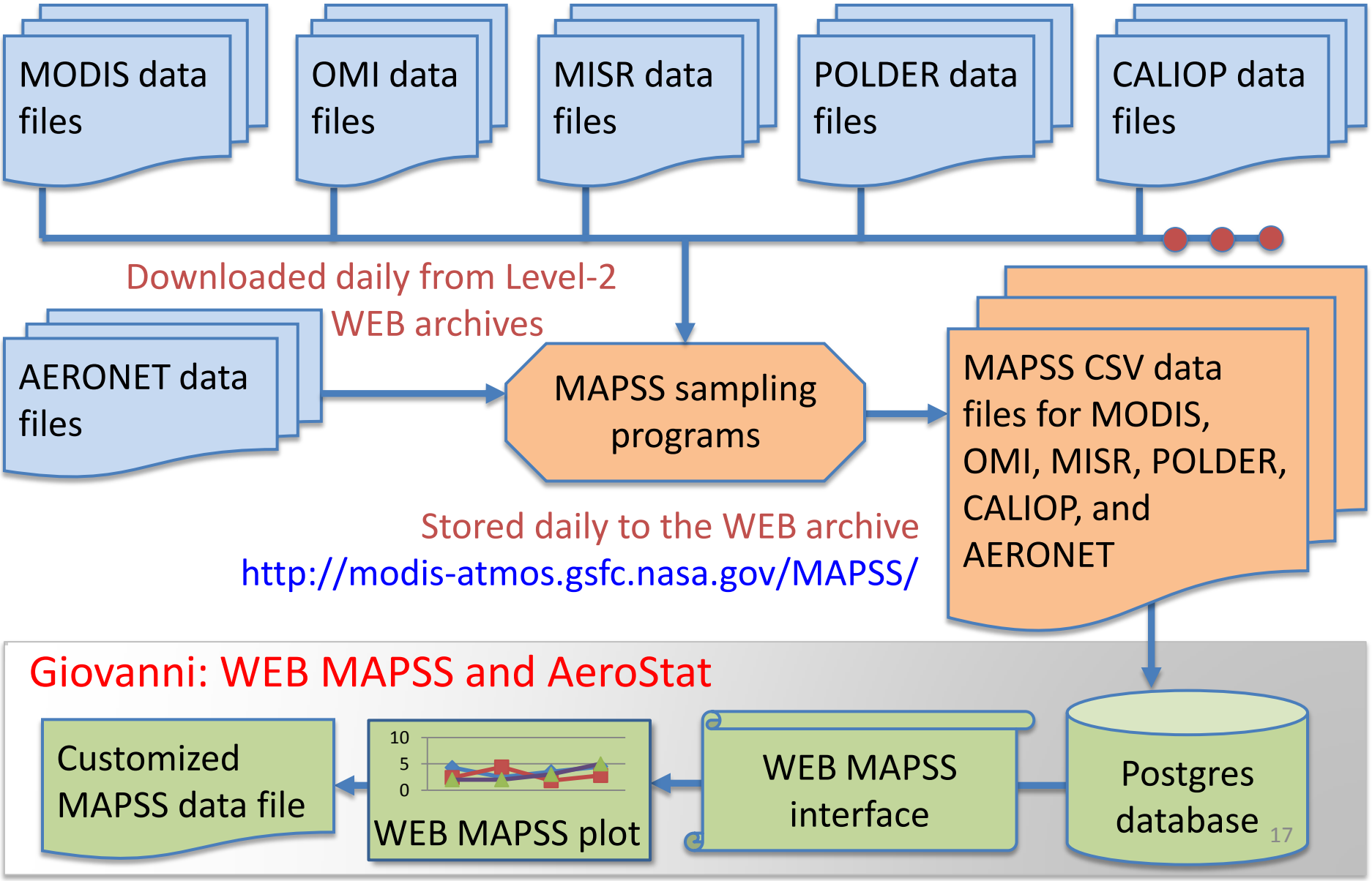
MODIS data with **all** QA



MODIS data with **best** QA

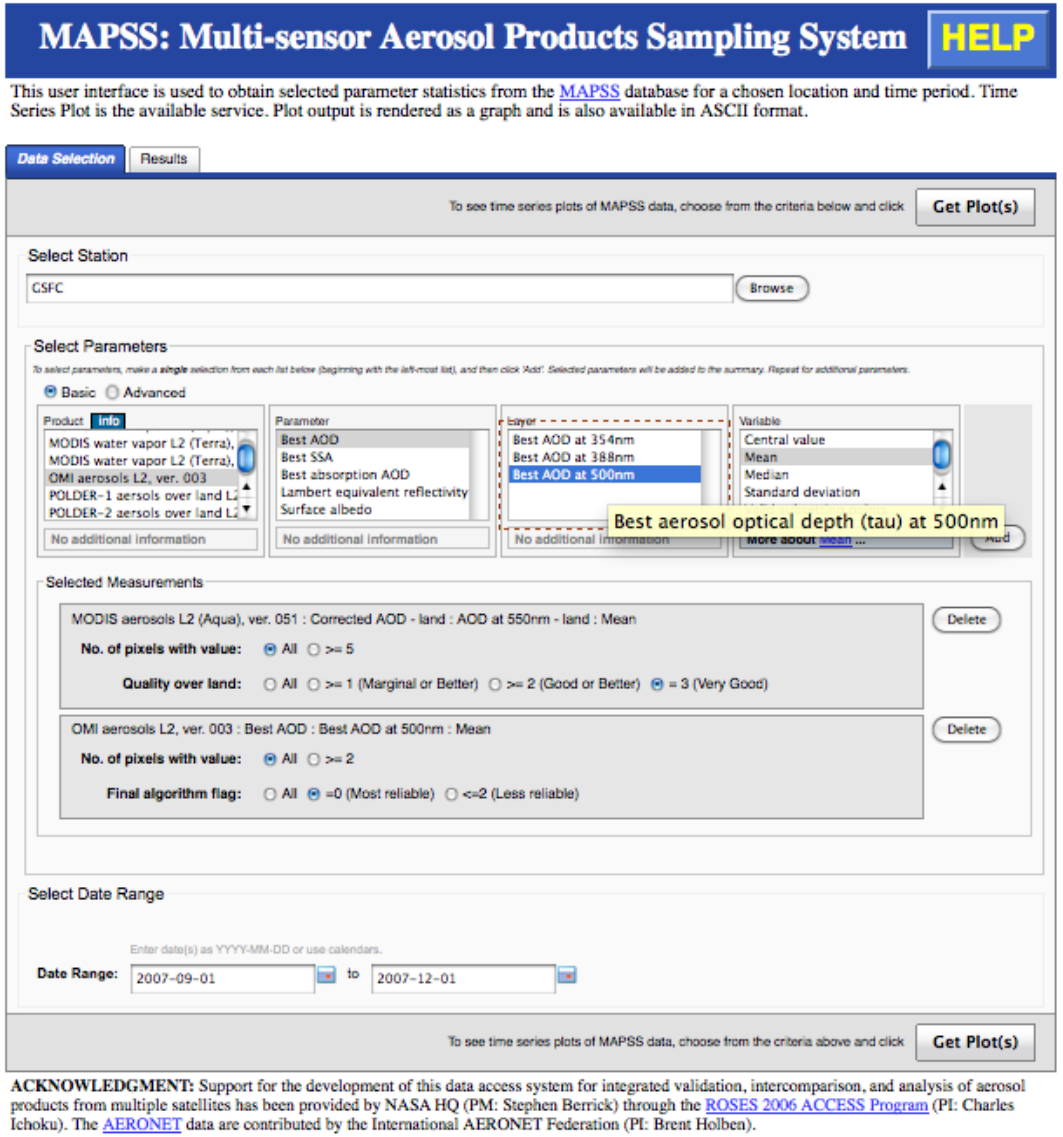


MAPSS workflow



MAPSS in Giovanni (WEB MAPSS)

- Interactive MAPSS data analysis system
- Online plotting
  - Time series
  - Scatter plot (coming)
- Customized CSV files with selected MAPSS data
- Interactive data filters
  - QA (with explanations!)
  - nval (number of sampled pixels with non-fill values)
- Condensed documentation for the supported products



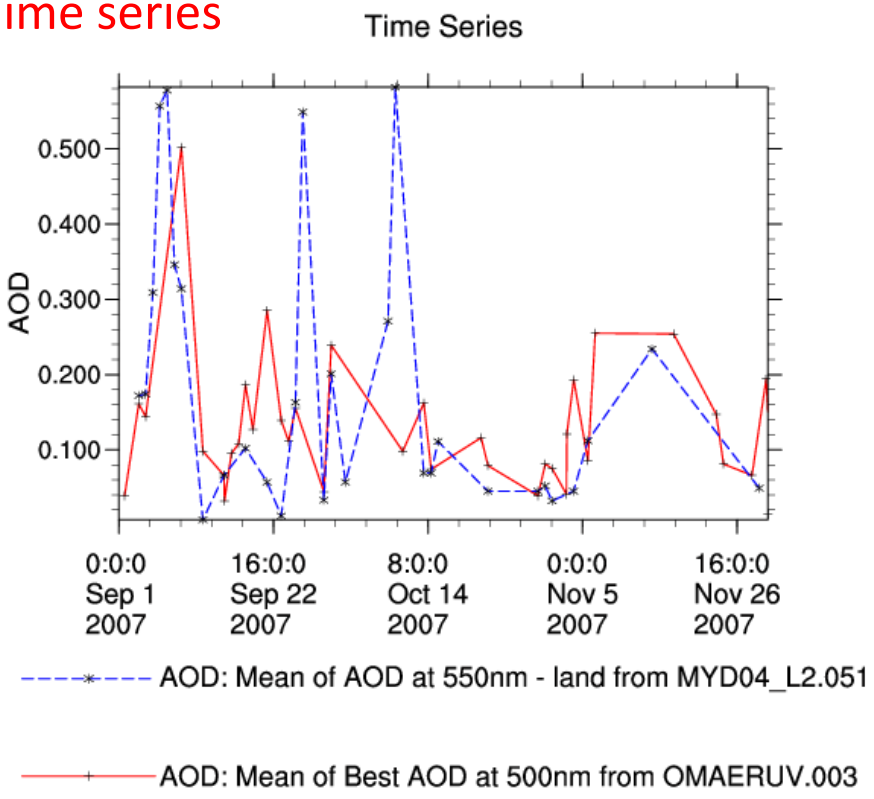
http://giovanni.gsfc.nasa.gov/mapss/

AOD Data quality information

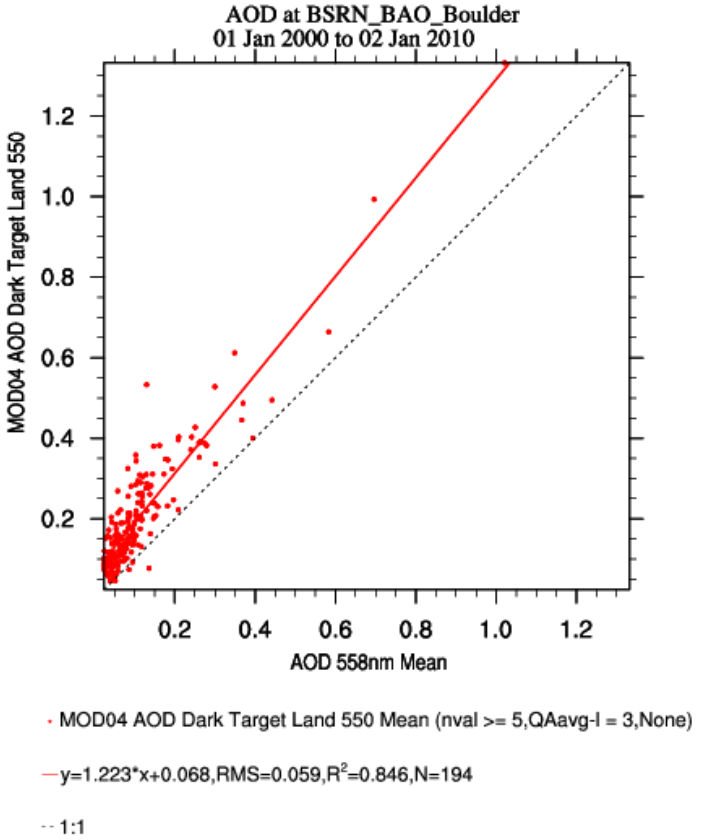
Sensor	QA summary
AERONET	No QA flags, data at Level-2 is quality assured
MODIS	Integer flags, 0..3 (0=Bad, 3=Good)
MISR	Integer flag, 0..3 (0=Good, 3=Bad)
OMI	Integer flag, 0..7 (0=Good, 3..7=Bad)
POLDER	Combination of several real numbers, [0..1] [Bad .. Good]
CALIOP	Combination of several real numbers, [0..1] [Bad .. Good]
SeaWiFS	Integer flags, 0..3 (0=Bad, 3=Good)

WEB MAPSS outputs

Time series



Scatter plot*

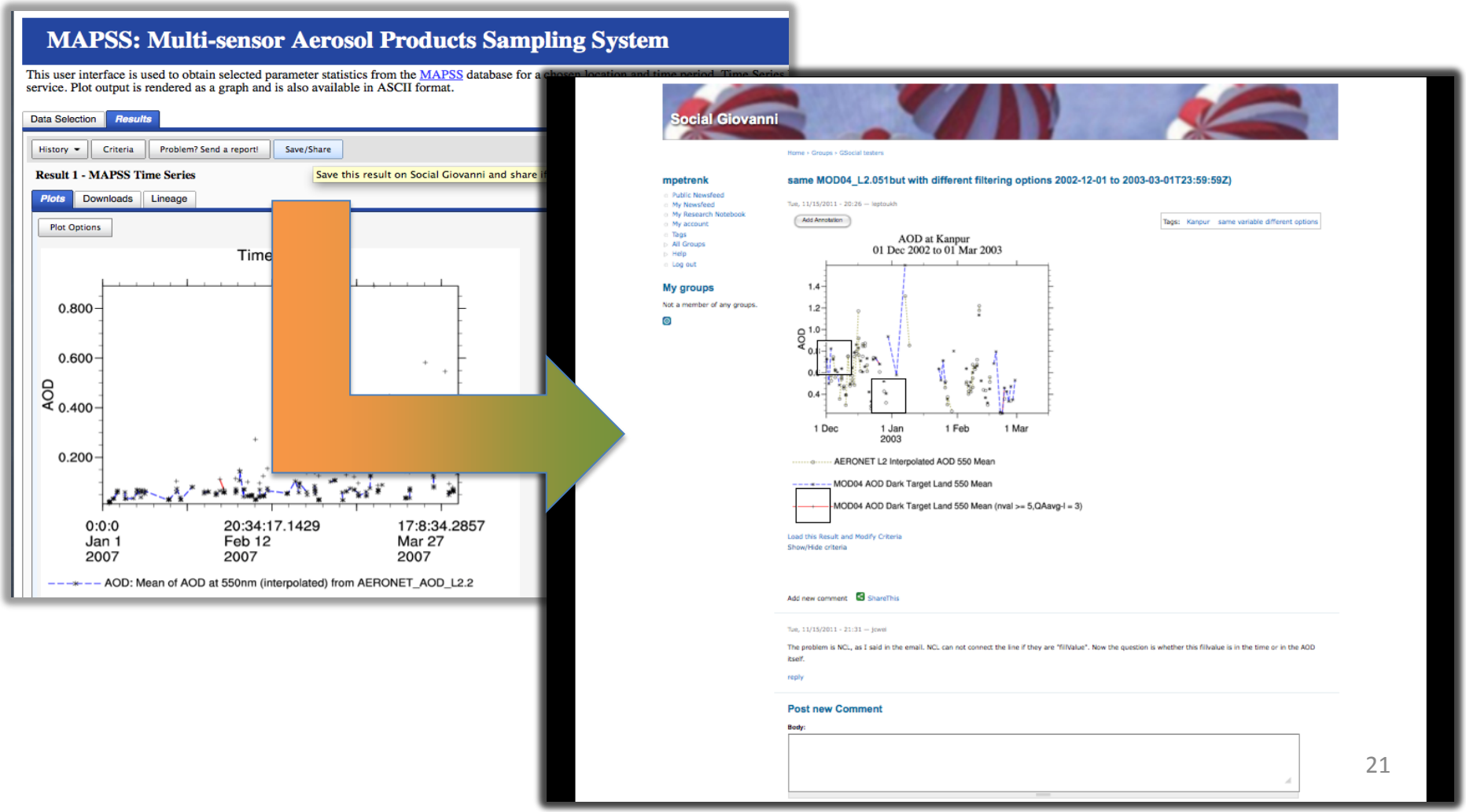


Comma-separated (CSV) data file

Title: MAPSS MAPSS Time Series				
Start date: 2006-01-01				
End date: 2007-12-31				
Station(s):				
datetime	mean_AERONET_AOD_L2_2_AOD0670_Dakar	mean_MOD04_L2_051_AOD0660corr_l_Dakar	mean_MYD04_L2_051_AOD0660corr_l_Dakar	mean_MIL2ASAE_0022_AOD0672b_Dakar
1/1/06 12:20	0.38	0.19		
1/4/06 14:15			0.49	
1/5/06 11:55		0.11		
1/9/06 11:30	0.22	-0.04		
1/9/06 14:33			-0.01	
1/12/06 12:00		0.14		
1/13/06 14:09	0.23		0.1	
1/13/06 14:24	0.23			
1/14/06 11:45	0.3	0.18		
1/14/06 11:49				0.08

GSocial

FaceBook-like social networking system for sharing and discussing results of aerosol analysis in Giovanni

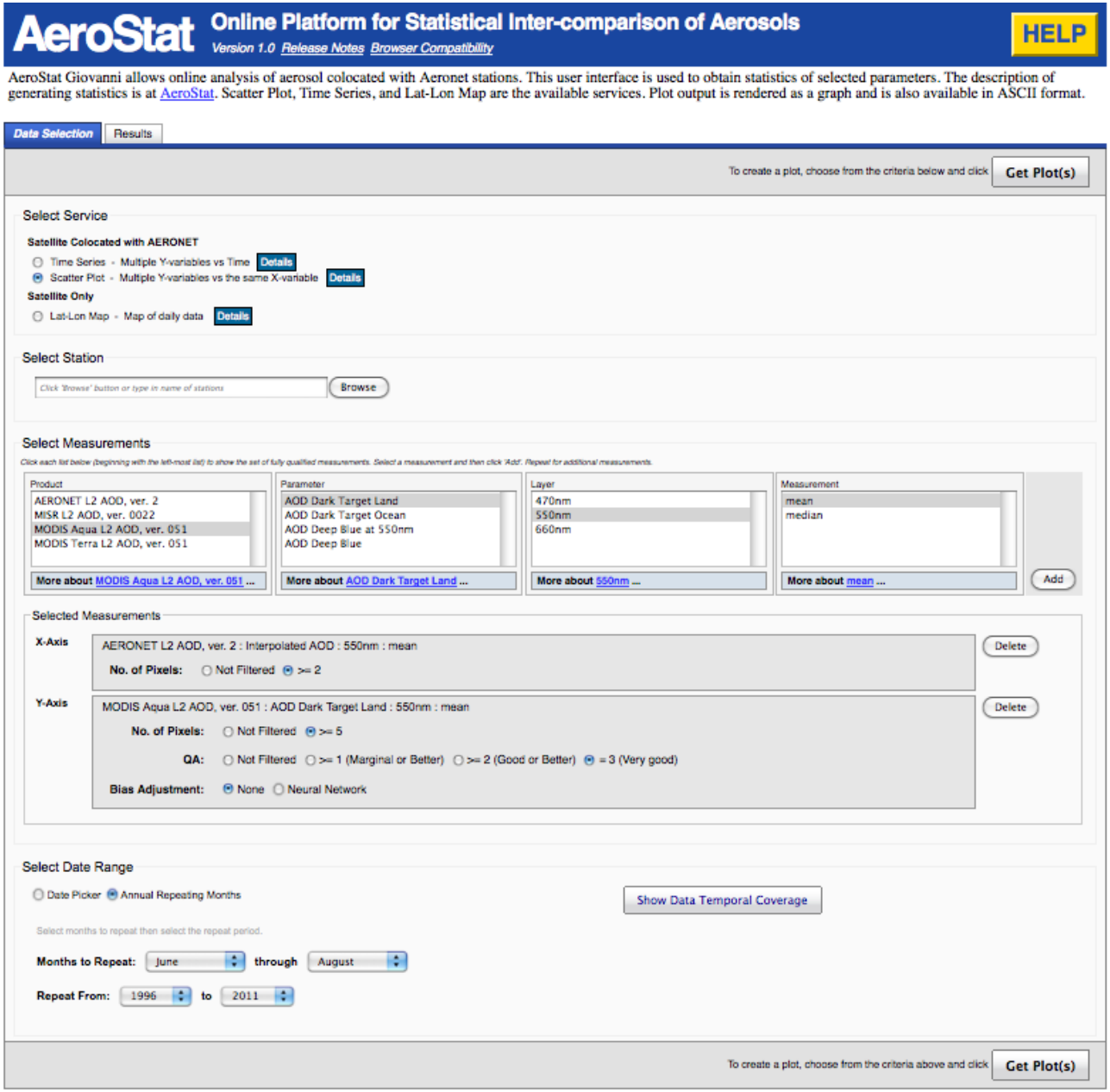


AeroStat

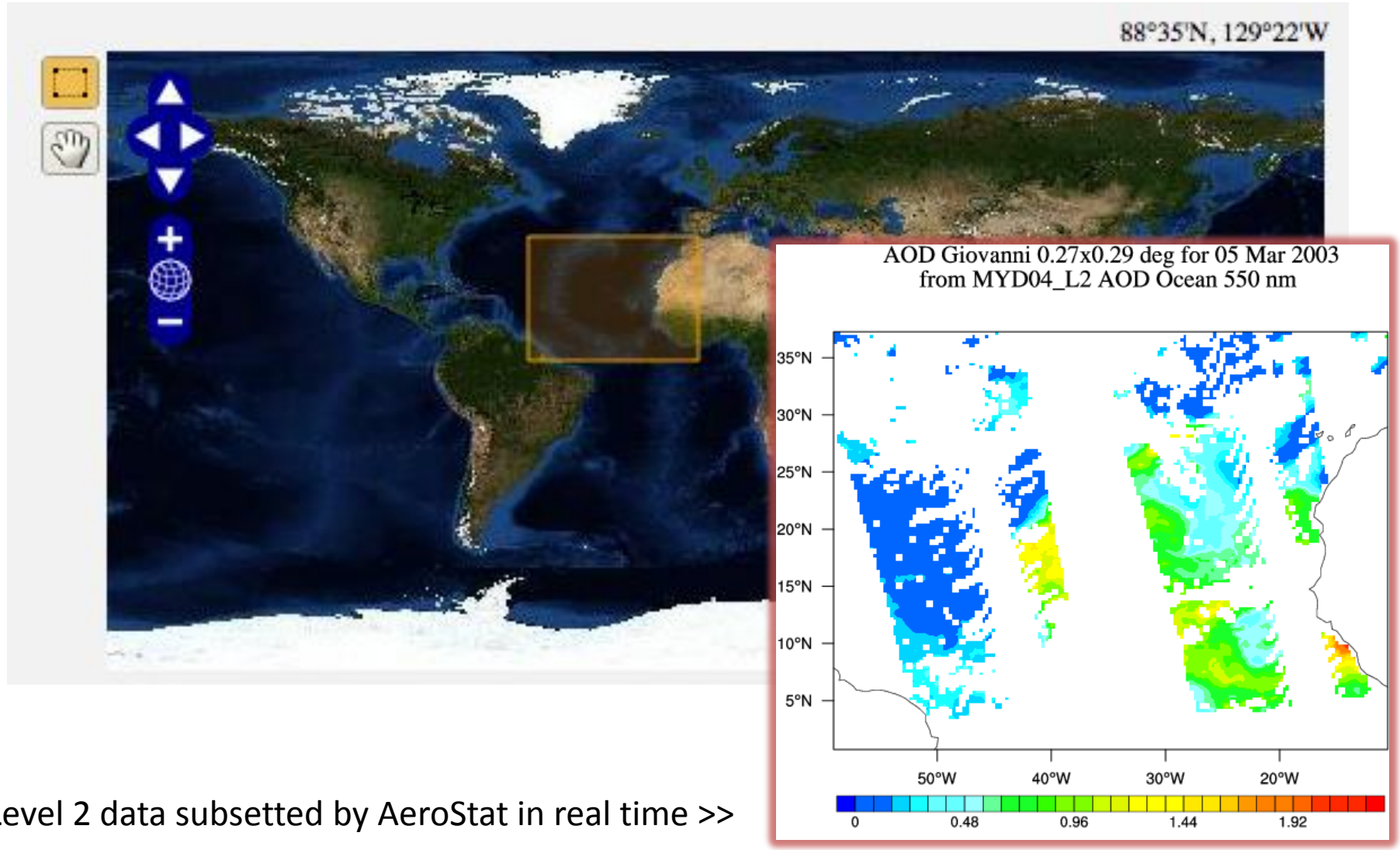
- System for statistical analysis and correction of the systematic biases that might exist in aerosol measurements
  - Neural network algorithm uses MAPSS co-located data to "learn" about possible biases in the measurements, in relation to the corresponding measurement conditions
    - E.g., AOD can be overestimated if cloud fraction is high
  - The learned properties of the data can be used to correct the biases in the original Level-2 data
    - E.g., reduce retrieved AOD for pixels with high cloud fraction

AeroStat in Giovanni

- Simplified interface
- Provided data
  - MAPSS data
  - Level 2 data
    - Subsetted "on the fly"
- Bias adjustment
- Plotting
  - Time series
  - Scatter plot
  - Lat/Lon map
- Annual repeating month date range



AeroStat: Lat/Lon map



Level 2 data subsetted by AeroStat in real time >>

Summary

- MAPSS provides the consistent and convenient framework for integrated analysis and validation of aerosol products from multiple sensors
- Aerosol products are sampled by the MAPSS system on a daily basis and served through the FTP archive of CSV files, and also through the interactive MAPSS and AeroStat Giovanni interfaces
- The unified format and structure of the sampled data sets facilitates automated analysis of the uncertainties in aerosol retrievals

Future

- Aerosol uncertainty analysis and exploration tool (interactive scatter plot, map, etc)
- Extended support for Level-2 data plotting and analysis
- User-configurable Level-2 data merging, accounting for uncertainties
- Multi-faceted search and GUI redesign (also, update data access!)
- Improved collaborative capabilities

Acknowledgement

- NASA HQ Program Managers:
  - Hal Maring.
  - Martha Maiden.
  - Steve Berrick.

  For tag-team Funding support of this series of projects.

- Aerosol Products Teams
  - AERONET: Brent Holben, David Giles, Ilya Slutsker
  - MODIS: Lorraine Remer, Rob Levy
  - MISR: Ralph Kahn
  - OMI: Omar Torres
  - POLDER: Didier Tanre, Fabrice Ducos, Jacques Descloitres
  - CALIOP: Dave Winker, Ali Omar
  - SeaWiFS: Christina Hsu

- Giovanni Team